Section 2

Waste Disposal and Recycling

Objectives

After this lesson, students will be able to

E.4.2.1 Name three methods of solid waste disposal.

E.4.2.2 Identify ways people can help control the solid waste problem.

E.4.2.3 Explain how hazardous wastes can be safely disposed of.

Target Reading Skill

Asking Questions Explain that changing a head into a question helps students anticipate the ideas, facts, and events they are about to read.

Answers

Possible questions and answers include the following: **What is the problem with waste disposal?** *(Each disposal method has advantages and disadvantages.)* **What is recycling?** *(Reclaiming raw materials and reusing them to create new products.)* **How can people help control the solid waste problem?** *(Reduce, reuse, and recycle.)* **Why are some wastes hazardous?** *(Some are explosive, flammable, corrosive, or radioactive.)*

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Preteach

Build Background Knowledge

L2

Getting Rid of Solid Waste

Ask: **What kinds of things does your family throw away?** *(Used paper, metal cans, glass jars, plastic milk jugs, and so on)* **How does your family get rid of its trash?** *(Trash may be collected in the students' community, or families may bring it to a "dump" themselves. Some families may recycle part of their trash.)*

Section 2

Waste Disposal and Recycling

Reading Preview

Key Concepts

- What are three methods of handling solid waste?
- What can people do to help control the solid waste problem?
- How can hazardous wastes be safely disposed of?

Key Terms

- municipal solid waste
- incineration
- leachate
- sanitary landfill
- recycling
- biodegradable
- composting
- hazardous waste

Target Reading Skill

Asking Questions Before you read, preview the red headings. In a graphic organizer like the one below, ask a *why, what,* or *how* question for each heading. As you read, write the answers to your questions.

The Problem of Waste Disposal

Question	Answer
What is the problem with waste disposal?	Each disposal method has . . .

Lab zone Discover Activity

What's in the Trash?

Your teacher will give you a trash bag. The items in the bag represent the most common categories of household waste in the United States.

1. Before you open the bag, predict what the two most common categories are.
2. Put on some plastic gloves. Open the bag and sort the trash items into categories based on what they are made of.
3. Count the number of trash items in each category. Construct a bar graph showing the number of pieces of trash in each category.

Think It Over

Interpreting Data Based on your graph, what are the two most common types of household waste? Was your prediction correct?

How much trash does your family throw away in a year? If it's your job to take the trash out, you might say that it's a large amount. Now imagine that amount multiplied by every family in the United States! Consider these facts:

- Every hour, people throw away about 2.5 million plastic bottles.
- Every day, the average person produces about 2 kilograms of trash.
- Every year, people throw away 2.8 million metric tons of plastic bags and 230 million automobile tires.

You can see why some people call the United States a "throw-away society"! Disposable products can be cheap and convenient. But they have created a big problem—what to do with all the trash.

Lab zone Discover Activity

Skills Focus Interpreting data L1

Materials trash bag containing common household wastes, plastic gloves, graph paper, ruler. For each group of students, prepare a trash bag containing the following items: 4 paper items; 2 items of yard waste such as leaves; 1 piece of rubber, cloth, or wood waste; 1 soda can or other metal item; 1 glass jar or bottle; 1 plastic item; 1 food-waste item, such as an orange peel

Time 20 minutes

Tips Have students work on the floor so glass containers do not fall and break.

Expected Outcome Students will sort the items into the categories listed.

Think It Over Paper and yard waste

The Problem of Waste Disposal

In their daily activities, people generate many types of waste, including used paper, empty packages, and food scraps. The waste materials produced in homes, businesses, schools, and other places in a community are called **municipal solid waste.** Other sources of solid waste include construction debris and certain agricultural and industrial wastes. **Three methods of handling solid waste are burning, burying, and recycling. Each method has advantages and disadvantages.**

Incineration The burning of solid waste is called **incineration** (in sin ur AY shun). Incineration has some advantages. The burning facilities, or incinerators, do not take up much space. They do not pose a risk of polluting groundwater. The heat produced by burning solid waste can be used to generate electricity. These "waste-to-energy" plants supply electricity to many homes in the United States.

Unfortunately, incinerators do have drawbacks. Even the best incinerators release some pollution into the air. And although incinerators reduce the volume of waste by as much as 90 percent, some waste still remains. This waste needs to be disposed of somewhere. Finally, incinerators are expensive to build.

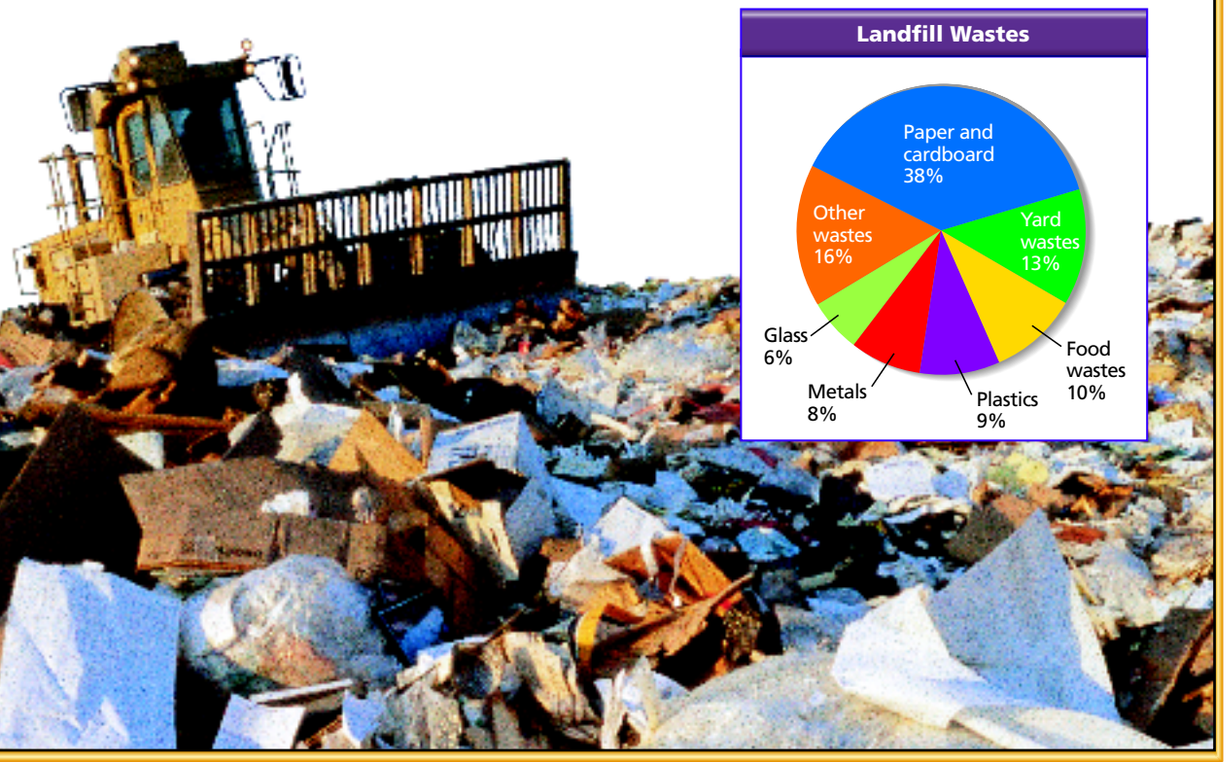


FIGURE 6
Waste Disposal
Billions of tons of municipal solid waste are created in the United States each year. More than one third of that waste is paper.
Reading Graphs *What percentage of solid waste does food waste represent?*

Differentiated Instruction

English Learners/Beginning L1
Comprehension: Key Concept On the board, rewrite the boldface sentence into individual sentences, e.g., *One method of handling solid waste is burning.* Explain each method. Then have students construct a concept map with *Methods of Solid Waste Disposal* in the center and the methods connected to the center by lines. **learning modality: verbal**

English Learners/Intermediate L2
Comprehension: Key Concept Read aloud the boldface sentence. Ask students to describe each method of disposal. Then pair English learners with students who are proficient in English to work together to summarize the passages for each heading. **learning modality: verbal**

Instruct

The Problem of Waste Disposal

Teach Key Concepts L2

Disposal of Solid Wastes

Focus Have students look at the picture on this page and name items they throw away that might end up in a landfill.

Teach Explain that solid waste can be disposed of by incineration or by burying it in landfills. Ask: **What are the advantages of incineration?** *(Incinerators take up little space, do not pollute groundwater, and produce heat that can be used to generate electricity.)* **Disadvantages?** *(They release pollution, do not completely destroy the solid waste, and are expensive to build.)* Ask: **What are the advantages of sanitary landfills over open dumps?** *(They prevent leachate from contaminating groundwater, contain wastes more safely, and are not as unsightly.)* **Disadvantages?** *(They still can pollute groundwater, and the uses of capped landfills are limited.)*

Apply Have students examine Figure 6. As a class, create a similar circle graph reflecting the amount and types of trash thrown out by all students. **learning modality: logical/mathematical**

Extend The Active Art will show students the components of a well-designed sanitary landfill.

All in One Teaching Resources
- Transparency E35

Independent Practice

All in One Teaching Resources
- Guided Reading and Study Worksheet: *Waste Disposal and Recycling*

Student Edition on Audio CD

Monitor Progress L2

Skills Check Have each student construct a table to compare and contrast incineration and disposal in landfills.

Answers
Figure 6 10%

Go Online active art

For: Landfill activity
Visit: PHSchool.com
Web Code: cep-5042

Students learn about the components of a well-designed sanitary landfill.

Lab zone Teacher Demo L1

Making a Model of a Landfill

Materials beaker, coffee filter, food coloring, jar, rubber band, soil, water

Time 10 minutes

Focus Review the meaning of *leachate.*

Teach Put a coffee filter over the mouth of a jar, letting it hang into the jar, and secure it in place with a rubber band. Fill the filter about halfway with soil. Put several drops of food coloring on the soil, and then pour water into the jar. After the water has collected in the jar, ask: **What do you see in the jar?** *(Colored water)* **Where did the color come from?** *(The food coloring)* **What does the food coloring represent in this landfill model?** *(Chemicals in the soil)*

Apply Ask: **In a real landfill, where do chemicals come from?** *(The wastes in the landfill)* **learning modality: visual**

Use Visuals: Figure 7 L2

Reducing Health and Safety Risks

Focus Remind students why sanitary landfills were developed.

Teach Ask different volunteers to read the captions aloud. Ask: **How is this landfill designed to reduce health risks?** *(Vent pipes release gases that might cause an explosion. Wells are monitored for wastes polluting groundwater. Leachate forms at the bottom rather than running off into surrounding water. Liners keep liquids from leaking into the soil.)*

Apply Remind students that even well-designed landfills do not prevent all leakage. Ask: **What can people do to further decrease the risk of pollution from landfills?** *(Reduce the amount of landfill waste that could be poisonuous, such as pesticides.)* **learning modality: visual**

Go Online active art

For: Sanitary Landfill activity
Visit: PHSchool.com
Web Code: cep-5042

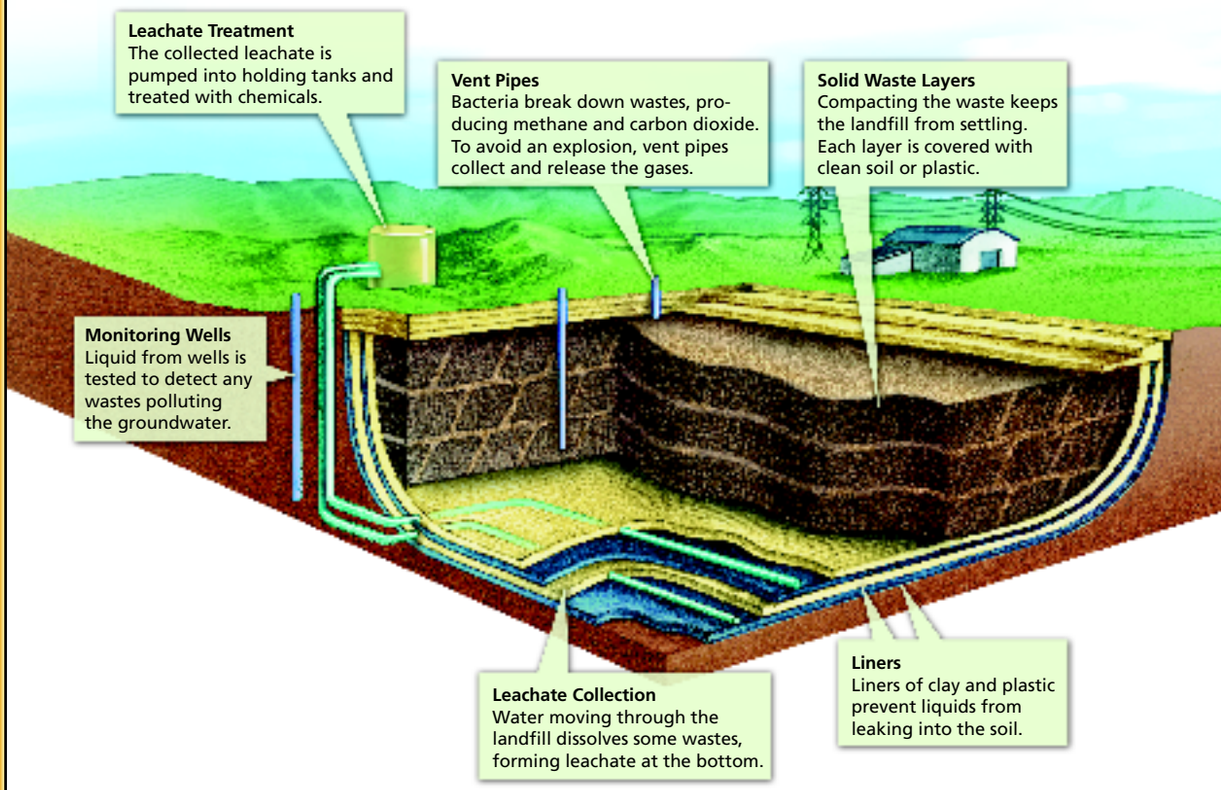
FIGURE 7
Sanitary Landfill
A well-designed sanitary landfill contains the waste and prevents it from polluting the surrounding land and water.

Landfills Until fairly recently, people usually disposed of waste in open holes in the ground. But these open dumps were dangerous and unsightly. Rainwater falling on a dump dissolved chemicals from the wastes, forming a polluted liquid called **leachate.** Leachate could run off into streams and lakes, or trickle down into the groundwater below the dump.

In 1976, the government banned open dumps. Now much solid waste is buried in landfills that are constructed to hold the wastes more safely. A **sanitary landfill** holds municipal solid waste, construction debris, and some types of agricultural and industrial waste. Figure 7 shows the parts of a well-designed sanitary landfill. Once a landfill is full, it is covered with a clay cap to keep rainwater from entering the waste.

However, even well-designed landfills still pose a risk of polluting groundwater. And while capped landfills can be reused in certain ways, including as parks and sites for sports arenas, they cannot be used for housing or agriculture.

Reading Checkpoint **What are two possible uses of a capped sanitary landfill?**



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- Transparency E31

FIGURE 8
Metal Recycling
Metal is a commonly recycled material. Here, crumpled aluminum cans ride up a conveyor belt in a recycling center. **Predicting** *Without recycling, what might eventually happen to the supply of aluminum?*

Recycling

The process of reclaiming raw materials and reusing them to create new products is called **recycling.** Recycling reduces the volume of solid waste by enabling people to use the materials in wastes again. While recycling uses some energy, it also saves the energy that would be needed to obtain and process raw materials.

As you know, matter in ecosystems is naturally recycled through the water cycle, carbon cycle, and other processes. Any material that can be broken down and recycled by bacteria and other decomposers is **biodegradable** (by oh dih GRAY duh bul). Unfortunately, many of the products people use today are not biodegradable. Plastic containers, metal cans, rubber tires, and glass jars are examples of products that do not naturally decompose. Instead, people have developed techniques to recycle the raw materials in these products.

A wide range of materials, including motor oil, tires, and batteries, can be recycled. Most recycling focuses on four major categories of products: metal, plastic, glass, and paper.

Metal In your classroom, you are surrounded by metal objects that can be recycled. Your desk, scissors, staples, and paper clips are probably made of steel. Another very common metal, aluminum, is used to make soda cans, house siding, window screens, and many other products.

Metals such as iron and aluminum can be recycled. Recycling metal saves money and causes less pollution than making new metal. With recycling, no ore needs to be mined, transported to factories, or processed. In addition, recycling metals helps conserve these nonrenewable resources.

Lab zone Skills Activity

Graphing

What happens to trash? Use the data in the table below to construct a circle graph of methods of municipal solid waste disposal in the United States. Give your circle graph a title. (For help making a circle graph, see the Skills Handbook.)

Method of Disposal	Percentage of Waste
Landfills	56%
Recycling	27%
Incineration	17%

Lab zone Skills Activity

Skills Focus Graphing L2

Materials protractor, drawing compass

Time 15 minutes

Tips Tell students to determine the size of each wedge of the circle graph by multiplying 360° by each percentage.

Expected Outcome *(Landfills = 202°, Recycling = 97°, Incineration = 61°; Possible title: Methods of Waste Disposal in the U. S.)*

Extend Have students make a second circle graph to show what would happen if 15% more of the total waste were recycled instead of being sent to landfills. *(Landfills = 148°, Recycling = 151°)* **learning modality: logical/mathematical**

Recycling

Teach Key Concepts L2

Metal, Plastic, Glass, and Paper Recycling

Focus Ask students to give examples of items that are recyclable.

Teach Ask: **What is an example of recycling in nature?** *(Matter is naturally recycled through the water cycle, carbon cycle, and other processes.)* Explain that biodegradable matter naturally decomposes. Ask: **What are some items that are not biodegradable or that degrade very slowly?** *(Plastic containers, metal cans, glass containers)* **What are the benefits of recycling aluminum cans and other metals?** *(It takes less energy to recycle the cans than to mine the raw materials and process the ore. It also saves money and causes less pollution.)* **What are plastic products that can be recycled?** *(Milk jugs, detergent containers, and soda bottles)* **Why can most paper products be recycled only a few times?** *(Each time paper is recycled to make pulp, the new paper is rougher, weaker, and darker.)*

Apply Ask: **Do you think recycling is worth the extra effort? Why?** *(Accept logical responses. Most students will say that recycling is worth the effort because it helps prevent the supply of certain materials from running out or that it helps prevent landfills from filling up.)* **learning modality: verbal**

Monitor Progress L2

Oral Presentation Call on students at random to explain why metal, plastic, glass, and paper should be recycled instead of being discarded in landfills.

Answers

Figure 8 The supply might be used up.

Reading Checkpoint Parks and sites for sports arenas

Integrating Technology L1

Have small groups of students select a product labeled "biodegradable" to bury on the school grounds. Advise each group to select an item made of a different material. At the end of this chapter, have the groups dig up their items to see which materials began to decompose. Ask students to explain why some items may not appear to have begun decomposing. *(Possible answer: The materials in the item may take longer to break down.)* **CAUTION:** *Have students wear plastic gloves when handling trash and wash their hands afterward. Students who are allergic to molds should not participate.* **learning modality: kinesthetic**

Lab zone Build Inquiry L2

Calculating Trees to Make Newspaper

Materials calculator (optional), metric ruler, newspapers

Time 10 minutes

Focus Show students a stack of one week's issues of newspaper that you have collected. Ask them to estimate how many newspapers they think one tree can make.

Teach Explain that one tree 10.5 to 12 m tall produces a stack of newspapers 1.2 m high. Have a volunteer measure the height of the stack. Ask: **In how many weeks would I use up one tree by reading the newspaper?** *(120 cm ÷ height of stack)* **How many trees in a year?** *(52 ÷ weeks to use one tree)*

Apply Ask: **If every one of your families also read the newspaper every day, how many trees would we all use up in a year?** *(Above answer × [number of students] + yourself)* **learning modality: logical/mathematical**

FIGURE 9
Plastic Recycling
Plastic bottles can be recycled and made into many products, including polyester fleece for jackets.

Plastic When oil is refined to make gasoline and other petroleum products, solid materials called resins are left over. Resins can be heated, stretched, and molded into plastic products. Common plastic products that can easily be recycled include milk jugs, detergent containers, and soda bottles. When these products are recycled, they take on very different forms: as fleece jackets, carpeting, park benches, shower stalls, floor tiles, trash cans, fiber filling for sleeping bags, or even dock pilings!

Glass Glass is made from sand, soda ash, and limestone mixed together and heated. Glass is one of the easiest products to recycle because glass pieces can be melted down over and over to make new glass containers. Recycled glass is also used to make fiberglass, bricks, tiles, and the reflective paints on road signs.

Recycling glass is less expensive than making glass from raw materials. Because the recycled pieces melt at a lower temperature than the raw materials, less energy is required. Recycling glass also reduces the environmental damage caused by mining for soda and limestone.

Paper It takes about 17 trees to make one metric ton of paper. Paper mills turn wood into a thick liquid called pulp. Pulp is spread out and dried to produce paper. Pulp can also be made from old newspapers and old used paper. The paper must be washed to remove the inks and dyes. Then the paper is mixed with more water and other chemicals to form pulp.

Most paper products can only be recycled a few times. Recycled paper is not as smooth or strong as paper made from wood pulp. Each time paper is recycled to make pulp, the new paper is rougher, weaker, and darker.

Reading Checkpoint **What are three reasons to recycle glass?**

Lab zone Try This Activity

It's in the Numbers

Plastic bottles and other plastic products usually have a number inside a triangle indicating the type of plastic they are made of. Plastics must be sorted by type before they can be recycled.

Sort the plastic products your teacher gives you into groups according to their recycling numbers.

Classifying Compare and contrast the pieces in each group with one another and with the pieces in other groups. Describe the characteristics of each group.

Lab zone Try This Activity

Skills Focus Classifying L2

Materials pieces of plastic products. Assemble a set of plastic pieces by selecting several examples from each of these recycling categories: 1 (polyethylene terphthalate) soft-drink bottles, 2 (high-density polyethylene) milk and water jugs, 3 (vinyl) shampoo bottles, 4 (low-density polyethylene) ketchup bottles, 5 (polypropylene) squeeze bottles, 6 (polystyrene) fast-food containers and coffee cups, 7 (all other resins and layered multi-materials). To reduce preparation time, assemble one set of plastic pieces and let students take turns sorting the pieces.

Time 10 minutes

Tips **CAUTION:** *Use only empty containers that have not held any hazardous materials. Rinse or wash out containers thoroughly.*

Expected Outcome The plastics can be sorted into at least four or five groups according to the plastics' color, clarity, and rigidity.

Extend Have students make a compare/contrast table listing the types, descriptions, and uses of the different groups of plastics. **learning modality: logical/mathematical**

Is Recycling Worthwhile? Besides conserving resources, recycling also saves energy. For example, making aluminum products from recycled aluminum rather than from raw materials uses about 90 percent less energy overall. For certain materials, recycling is usually worthwhile.

But recycling is not a complete answer to the solid waste problem. For some cities, recycling is not cost-effective. Scientists have not found good ways to recycle some materials, such as plastic-coated paper and plastic foam. Some recycled products, such as low-quality recycled newspaper, have few uses. And all recycling processes require energy and create pollution. The value of recycling must be judged on a case-by-case basis.

What People Can Do

The good news is that there are ways individuals can help control the solid waste problem. **These are sometimes called the "three R's"—reduce, reuse, and recycle.** *Reduce* refers to creating less waste in the first place. For example, you can use a cloth shopping bag rather than a disposable paper or plastic bag. *Reuse* refers to finding another use for an object rather than discarding it. For example, you could refill plastic drink bottles with drinking water instead of buying new bottles of water.

As you have read, *recycle* refers to reclaiming raw materials to create new products. You can take the first step in the recycling process by recycling at home and by encouraging others to recycle. You can also make an effort to buy products made from recycled materials. This makes it more profitable for companies to use recycled materials in their products.

Another way to reduce the amount of solid waste your family produces is to start a compost pile. **Composting** is the process of helping biodegradable wastes to decompose naturally. The moist, dark conditions in a compost pile allow natural decomposers to break down waste more quickly. Compost piles can be used to recycle grass clippings, raked leaves, and some food wastes. Compost is an excellent natural fertilizer for plants.

FIGURE 10
Composting
Many kinds of food and yard waste can be composted.
Interpreting Photographs *How does composting help reduce household waste?*

Differentiated Instruction

Gifted and Talented L3
Converting Used Items Ask students to look around their homes for items that are typically used once and then discarded. Challenge students to think of ways to convert the items into items that would be useful at home or in school. Encourage students who are artistically gifted to create works of art. *(Examples: A used greeting card can be cut to make gift tags. Items can be turned into art or jewelry.)* **learning modality: kinesthetic**

What People Can Do

Teach Key Concepts L2

Ways to Control Solid Waste

Focus Remind students that not all materials can be recycled.

Teach Ask: **What are ways, in addition to recycling, to help control the solid waste problem?** *(Reducing waste in the first place and reusing an item before discarding it)* **How can people reduce the amount of biodegradable waste that ends up in landfills?** *(Through composting)*

Apply Ask students to name ways they have reduced, reused, and recycled. Start a list so that students can share their ideas with one another. **learning modality: verbal**

Lab zone Build Inquiry L3

Communicating the Three R's

Materials posterboard, markers

Time 30 minutes

Focus Ask students to imagine they are responsible for community education about recycling.

Teach Divide students into small groups, and challenge them to think of a creative way to communicate the "three R's" to their community. Students might choose to develop public service announcements, campaign slogans, posters, songs, or skits. Messages should include the locations of places in the community where items can be recycled.

Apply Arrange for students to present their program in a public forum, such as a school assembly, a parent-teacher meeting, or a civic association meeting. **learning modality: verbal**

Monitor Progress L2

Writing Have students briefly explain the benefits of the three R's compared with discarding waste materials in landfills or burning them. Students can save their explanations in their portfolios. Portfolio

Answers

Figure 10 It reduces the amount of solid waste incinerated or added to landfills.

Reading Checkpoint It is less expensive than making it from raw materials, requires less energy, and reduces environmental damage from mining.

Hazardous Wastes

Teach Key Concepts L2

Types of Hazardous Materials

Focus Tell students that hazardous wastes are sometimes not easy to identify.

Teach Have students look at each of the signs pictured in Figure 11 and read the captions. Discuss each type of waste and how it might be harmful. Ask: **What is a radioactive material?** *(A material that contains unstable atoms that give off radiation that can cause health problems)* **What is a flammable material?** *(A material that can catch fire easily)* **How do corrosive substances affect materials?** *(They eat through them.)* **What effect would a toxic substance have on the body?** *(It acts as a poison to harm the body.)* **How should hazardous wastes be disposed of?** *(In carefully designed landfills, by incineration, by being broken down by living organisms, or by storage in deep rock layers)*

Apply Have students brainstorm ways to reduce the use of hazardous materials. *(Possible answers: Use rechargeable batteries. Buy only nontoxic arts and crafts supplies.)*
learning modality: logical/mathematical

Help Students Read L1

Active Comprehension Have students read the subheads under the main heading. Then ask: **What would you like to know about hazardous wastes?** *(Possible answers: What types of waste are considered hazardous? What are the effects of hazardous wastes?)* Write student questions on the board. After students finish reading pages 128–129, ask them to respond to each question.

Category: Toxic
Example: Chlorine

Category: Explosive
Example: Nitroglycerin

Category: Flammable
Example: Kerosene

FIGURE 11
Hazardous Materials
Vehicles transporting dangerous materials must use signs like these to alert people of the potential dangers of their loads.

Hazardous Wastes

Many people picture hazardous wastes as bubbling chemicals or oozing slime. But any material that can be harmful to human health or the environment if it is not properly disposed of is a **hazardous waste.**

Types of Hazardous Wastes Hazardous wastes are classified into four main categories. Toxic, or poisonous, wastes, can damage the health of humans and other organisms. Explosive wastes either react very quickly when exposed to air or water, or explode when they are dropped. Flammable wastes catch fire easily. Corrosive wastes can dissolve many materials.

Other wastes that require special disposal are radioactive wastes. Radioactive wastes give off radiation that can cause cancer and other diseases. Some radioactive waste can remain dangerous for thousands of years.

Health Effects A person can be exposed to hazardous wastes by breathing, eating, drinking, or touching them. Even short-term exposure to hazardous wastes can cause health problems such as skin irritation or breathing difficulties. Long-term exposure can cause diseases, such as cancer, damage to body organs, or death.

Disposal Methods It is difficult to dispose of hazardous wastes safely. Hazardous wastes are most often disposed of in carefully designed landfills. The landfills are lined and covered with clay and plastic. These materials prevent chemicals from leaking into the soil and groundwater. **Hazardous wastes that are not disposed of in carefully designed landfills may be incinerated or broken down by living organisms. Liquid wastes may be stored in deep rock layers.**

Scientists are still searching for methods that will provide safe, permanent disposal of radioactive wastes. Some radioactive wastes are currently stored in vaults dug hundreds of meters underground or in concrete and steel containers above ground.

Category: Corrosive
Example: Hydrochloric acid

Category: Radioactive
Example: Uranium

Disposal Sites It is even a challenge to decide where to build hazardous waste disposal facilities. In general, people would prefer to have a single large facility located in an area where few people live. However, it may be safer, cheaper, and easier to transport wastes to small local facilities instead.

Reducing Hazardous Waste The best way to manage hazardous wastes is to produce less of them in the first place. Industries are eager to develop safe alternatives to harmful chemicals. At home, you can find substitutes for some hazardous household chemicals. For example, use citronella candles instead of insect spray to repel insects.

Reading Checkpoint **What is the best way to manage hazardous wastes?**

Section 2 Assessment

Target Reading Skill **Asking Questions** Use the answers to the questions you wrote about the headings to help you answer the questions below.

Reviewing Key Concepts

1. **a.** **Reviewing** Name three ways of dealing with solid waste.
   b. **Comparing and Contrasting** Describe one advantage and one disadvantage of each method.
   c. **Developing Hypotheses** Near a former open dump, there is a stream in which your older relatives used to fish. No one fishes there anymore, however, because there are no fish. What might have happened?
2. **a.** **Identifying** What is meant by the "three R's"?
   b. **Problem Solving** Give one example of how you could practice each of the "three R's."
3. **a.** **Listing** What are four ways to dispose of hazardous wastes safely?
   b. **Comparing and Contrasting** How do hazardous waste landfills differ from normal landfills?
   c. **Making Judgments** Do you think hazardous wastes should be treated and disposed of at one large central facility? Explain.

Lab zone **At-Home Activity**

Trash Weigh-In For one week, have your family collect its household trash in large bags. Do not include food waste. At the end of the week, hold a trash weigh-in. Multiply the total amount by 52 to show how much trash your family produces in a year. Can you come up with any ways to reduce your family trash load?

Lab zone **Chapter Project**

Keep Students on Track Advise students to finish selecting a product package to redesign. Encourage them to brainstorm several ideas for improving the product, including materials to use, and write down all of their ideas. Pair students to help each other weigh the pros and cons of each idea.

Lab zone **At-Home Activity**

Trash Weigh-In L2 If students' families already recycle, tell students to weigh the materials being recycled separately from the other materials. Let students report their findings in class.

Monitor Progress L2

Answers

Reading Checkpoint Produce less of them in the first place.

Assess

Reviewing Key Concepts

1. a. Burning, burying, recycling **b.** Possible answers: Incineration doesn't pollute groundwater but it can pollute air. Burying waste in a sanitary landfill can possibly pollute groundwater, but the land later can be used for parks and sports arenas. Recycling conserves nonrenewable resources, but for some cities, it is not cost-effective. **c.** The dump may have produced a leachate that polluted the stream, killing all the fish. **2. a.** Reduce, reuse, recycle **b.** Possible answers: Use fewer paper towels to do a job; reuse plastic food containers to hold other household items; build a compost pile. **3. a.** Disposing of them in carefully designed landfills, incinerating, breaking down by organisms, and storing in deep rock layers **b.** Hazardous waste landfills are designed with liners and covers of clay and plastic. **c.** Answers may vary. Possible answer: A central facility might dispose of hazardous waste more efficiently, but transporting hazardous waste to a central facility would be more costly, difficult, and potentially dangerous than using several, small, local facilities.

Reteach L1

Name common consumer items, and ask students to tell whether each can be reduced, reused, or recycled, or a combination.

Performance Assessment L2

Writing Have each student write a paragraph in favor of or against mandatory recycling in a community using facts from this section to support their point of view.

All in One Teaching Resources

- Section Summary: *Waste Disposal and Recycling*
- Review and Reinforce: *Waste Disposal and Recycling*
- Enrich: *Waste Disposal and Recycling*

Waste, Away! L2

Prepare for Inquiry

Key Concept
A sanitary landfill prevents groundwater pollution more effectively than a poorly designed landfill or an open dump does.

Skills Objectives
Students will be able to
- observe how well different models of landfills protect groundwater from leachate
- make models of a sanitary landfill, a poorly designed landfill, and an open dump

Prep Time 20 minutes
Class Time Day 1, 40 minutes; Day 2, 20 minutes

All in One Teaching Resources
- Lab Worksheet: *Waste, Away!*

Advance Planning
Cut the cheesecloth and plastic pieces large enough to overlap the top of the jar when they are suspended in it, as shown in the photo. Cut extra pieces in case some tear when students add pebbles to them. Check the plastic pieces to make sure there are no holes in them.

Alternative Materials
If supplies are limited, have one third of the groups construct System 1, one third construct System 2, and one third construct System 3.

Safety
Remind students to wear lab aprons and safety goggles and handle the glass jars carefully. Review the safety guidelines in Appendix A.

Lab zone Skills Lab

Waste, Away!

Problem
How do different kinds of landfills work?

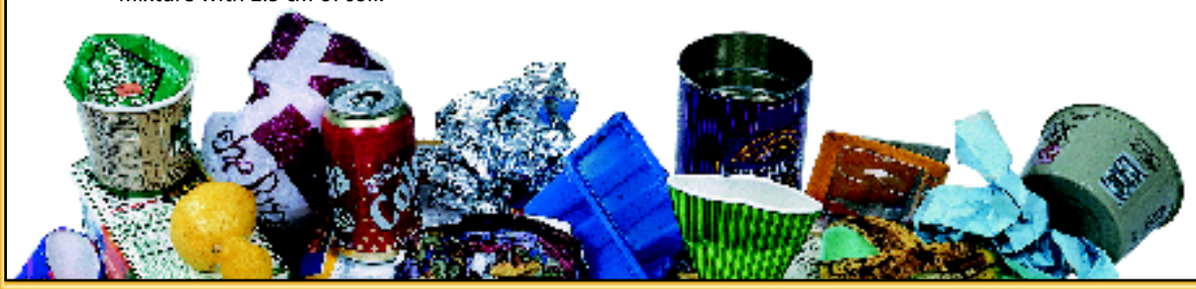
Skills Focus
observing, making models

Materials
- measuring cup
- metric ruler
- soil
- small pebbles
- cheesecloth
- scissors
- plastic wrap
- water
- newspaper
- 5 rubber bands
- red food coloring
- tweezers
- heavy-duty plastic bag
- 12 small sponge cubes
- 3 transparent, wide-mouthed jars

Procedure
1. Read over the entire procedure to preview the three landfill systems you will model. Determine which parts of the models represent potential drinking water, rainfall, solid waste, leachate, and the landfill systems themselves. Write a prediction about the way each system will repond to the test you'll conduct in Part 2.

PART 1 Modeling Three Different Landfill Systems
2. Obtain three identical jars. Label them System 1, System 2, and System 3. Pour clean, clear water into each jar to a depth of 5 cm.
3. Add equal amounts of small pebbles to each jar. The pebbles should be just below the surface of the water.
4. For System 1, cover the pebble and water mixture with 2.5 cm of soil.
5. For System 2, hang a piece of cheesecloth in the jar about 5 cm above the waterline, as shown in the photograph. Hold the cheesecloth in place with a rubber band around the outside mouth of the jar. Gently pour a handful of small pebbles into the cheesecloth.
6. For System 3, suspend a plastic bag in the jar about 5 cm above the waterline. Hold the bag in place with a rubber band around the outside mouth of the jar. Gently pour a handful of small pebbles into the plastic bag.
7. Observe the water and pebbles at the bottom of each of the systems. Record your observations.

PART 2 Testing the Systems
8. Soak 12 identical sponge cubes in water tinted with red food coloring. Use tweezers to place four soaked sponge cubes onto the top surface in each jar.
9. Cover the sponge cubes in Systems 2 and 3 with a thin layer of soil. Leave the sponge cubes in System 1 uncovered.
10. Make a labeled drawing of each system. Explain what each part of each of the models represents.
11. Pour 150 mL of water over each system. Then cover each jar with plastic wrap, and hold the wrap in place with a rubber band. Let the systems stand overnight.
12. Observe each landfill system. Note especially any changes in the color or clarity of the "groundwater." Record your observations.



Guide Inquiry

Invitation
Hold up a transparent drinking glass of clean tap water, and then drop a few small pieces of household waste into it. Ask: **Would you want to drink this water? Why or why not?** *(No; chemicals and disease-causing organisms in the trash pollute the water.)*

Introduce the Procedure
Invite students to read the entire lab procedure. Answer any questions they have. Explain that the models will represent three different types of landfills, but at this point do not discuss which type each model represents.

Analyze and Conclude

1. **Observing** Which part of each model represents the leachate? How well did each landfill system protect the groundwater from the leachate?
2. **Making Models** Identify which of your three models represent each of these three common types of landfills: a well-designed, or sanitary, landfill; a landfill with a poor design; and an open dump. Compare the way the three systems work.
3. **Predicting** If a community's landfill were not located immediately above its groundwater source, do you think its water supply would be completely protected? Explain.
4. **Communicating** Write a paragraph describing which landfill system would be safest for the environment. Use your observations to support your answer.

Design an Experiment

Solid waste can be compacted (crushed into smaller pieces), and the liquid in it can be removed before it is placed in a landfill. Does preparing the waste in this way make it safer for the environment? Write a hypothesis, and then use the ideas and procedures from this lab to design an experiment that tests your hypothesis. *Obtain your teacher's permission before trying your experiment.*

Extend Inquiry

Design an Experiment Compacting the waste takes less space and extends the life of the landfill, but does not remove harmful substances from the waste. It also keeps the wastes from settling inside the landfill. Removing liquid from the waste could reduce the amount of leachate produced. Students could model reduced-liquid waste by soaking the sponge cubes in food coloring, then squeezing the liquid out and allowing the cubes to dry thoroughly before placing them in the landfill models.

Troubleshooting the Experiment

- Circulate among groups as they build the models to make sure that the cheesecloth and plastic pieces are draped well down into the jars and are secured tightly with rubber bands.
- In Steps 4 and 5, caution students to add the pebbles gently so they do not tear the cheesecloth and plastic.
- When students draw the systems in Step 9, tell them to label the following elements: *groundwater* (water at bottom of jar), *soil*, *liner* (cheesecloth and plastic pieces), and *trash* (colored sponge cubes). Students could also label the pebbles *permeable layer*.

Expected Outcome

The groundwater in Systems 1 and 2 will turn red with "leachate"—food coloring from the sponge cubes. The water may also be cloudy with dissolved soil particles that have washed out of the landfills. The groundwater in System 3 will remain clear, with all of the leachate contained by the plastic liner.

Analyze and Conclude

1. The red-tinted water represented the leachate. Only System 3 protected the groundwater.

2. In System 1, an open dump, there is no barrier to separate waste from the soil and keep leachate from seeping into the groundwater. In System 2, a poorly designed landfill, the permeable liner contains the waste but allows leachate to seep into the groundwater. In System 3, a well-designed sanitary landfill, the plastic liner contains the leachate and keeps it from seeping into the groundwater.

3. Locating a landfill in an area that is not immediately above groundwater is safer. However, groundwater can still become contaminated if surface runoff from the landfill carries leachate to nearby rivers and streams or to permeable soil layers above groundwater supplies.

4. Paragraphs should include that a well-designed sanitary landfill (like System 3) is safest because it protects groundwater the best.